THE

INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL

PART IV

1932

CALCUTTA
PRINTED AT THE CATHOLIC ORPHAN PRESS
3 & 4 PORTUGUESE CHURCH STREET
1933

PLUCKING EXPERIMENTS

BY

H. R. Cooper

Results are quoted from experiments extending over six years at Borbhetta, Assam, also from experiments extending over two years at Tulsipara in the Dooars.

The Borbhetta Experiments.

The Borbhetta experiments are conducted on 64 parallel lines of 80 bushes each. Yields from each line were recorded over two years when all were under the same treatment. The area was then divided in 16 sets of 4 lines each, selected so that each set of four had given approximately the same yield in 1925 and 1926, irrespective of the position of the lines. To pay no attention to position was a mistake and has reduced the accuracy of the comparisons to a considerable extent. The eastern end of the area was originally much better than the western end, and remained so from about 1921 to 1927, but after that as manuring continued equally over the whole area, the two ends became more nearly equal, so that in later years sets which had a majority of lines in the originally better end, suffered relatively to sets with a majority of lines in the originally worse end. In addition, comparisons between yields of 320 bushes only, are subject to some error in measurement for a single year. The errors to which the measurements are subject can be gauged from the degree of agreement between repeats in the two cases where the same treatment was repeated on four different sets.

Errors of measurement and errors due to difference in seasonal effect on different parts of the area are very largely averaged out in the sums of the crops for 6 years.

In the case of the four sets of lines plucked at 6″ to the janam the greatest difference from the average (which being the average of 16 lines evenly scattered among 64 lines may be taken as accurate) is 1.8 mds., or 2.1% greater than the average.

In the case of the four similarly selected sets of lines plucked at 6″ and then a leaf once, the greatest difference from the average is 2.2 mds., or 2.8% greater than the average.

It may be assumed, therefore, that the six-year total for any treatment is accurate within about 3%, which is close enough for practical purposes.

When any one year is considered, we get maximum differences between any one set of four lines and the average :—

	1927	1928	1929	1930	1931	1932
	Mds.	Mds.	Mds.	Mds.	Mds.	Mds.
6″ to janam	·25	·35	·6	·35	·6	·35
6″ then 1 leaf then janam ...	·2	·2	·6	·6	·6	·55

The yield recorded for any one year from any set of four lines must be assumed to be possibly about 0.6 mds., (about 5%) higher or lower than the true average for the treatment given.

Each year bushes were pruned accurately level to the same height from the ground for all styles of plucking.

All lines were always plucked weekly (every Friday) in all six years, plucking orders being that all shoots of two-leaves-and-a-bud (however small) were to be taken or one soft *banjhi* leaf. From any shoots of three leaves and a bud, two leaves and a bud only were ordered to be taken and the third broken back, except where ordered to be left on the bush. Shoots of one leaf and a bud were supposed to be left, but pluckers usually took the larger of such shoots to save breaking back in the following week. Analysis of the pluck averaged about 5 to 10 per cent. one leaf and a bud, 70 to 80 per cent. two leaves and a bud, and about 5 per cent. each of small shoots of three and a bud, single *banjhis*, and double *banjhis* (small and soft).

Where a leaf was ordered to be left, a fully serrated leaf was left, as well as one, or perhaps two "janam" (unserrated) leaves, above the level of the previous plucking.

Where the "janam" only was left, plucking was either at the level of the previous plucking, if a "janam" was visible on the stalk left by the new plucking, or sufficiently far above the last plucking to leave a visible "janam". If there was a small "janam", and a bigger, round, unserrated leaf (*gol-pat*), both above the plucking level, only the small *janam* was left on the bush, the higher *janam* being broken back. If the smaller *janam* had dropped off, the bigger *janam* was left. This leaving of *janams* increased the height of the bush by about three inches above the original plucking level, in each year.

Where a big leaf was left at the second flush, height was similarly increased by about five inches by the end of the year.

On some gardens it is the practice to break back as nearly as possible to the original plucking level, even if no *janam* is left. The effect of such treatment compared to the above "plucking to the janam" has not been experimented with, and cannot be discussed here.

Results of the experiments tried are recorded in Table I.

Effect of leaving a leaf.

In the case of plucking over an initial growth of 6″ from the pruning level, the comparisons between plucking immediately to the *janam*, and leaving a big leaf (once only, on the second flush) are between averages of 16 lines of bushes, and may be considered accurate. The actual yields may be compared in table I and show a difference in crop in favour of plucking to the *janam* of 4.7 mds. tea per acre over 6 years or about 0.8 mds. tea annually, that is, about 6% loss from leaving the big leaf.

Compared to plucking to the *janam* taken as 100 crops from leaving the leaf are :—

	1927	1928	1929	1930	1931	1932
6″ to janam	100	100	100	100	100	100
6″ then 1 leaf then janam ...	90	91	91	95	97	102

In the cases of plucking over initial growths of 4″ and 8″ comparisons are not so accurate, being made between sets of four lines only, but the general trend of the results is similar to the above in each case.

	1927	1928	1929	1930	1931	1932
4″ to janam	100	100	100	100	100	100
4″ then 1 leaf then janam ...	91	90	90	96	95	99
8″ to janam	100	100	100	100	100	100
8″ then 1 leaf then janam ...	91	85	92	97	99	103

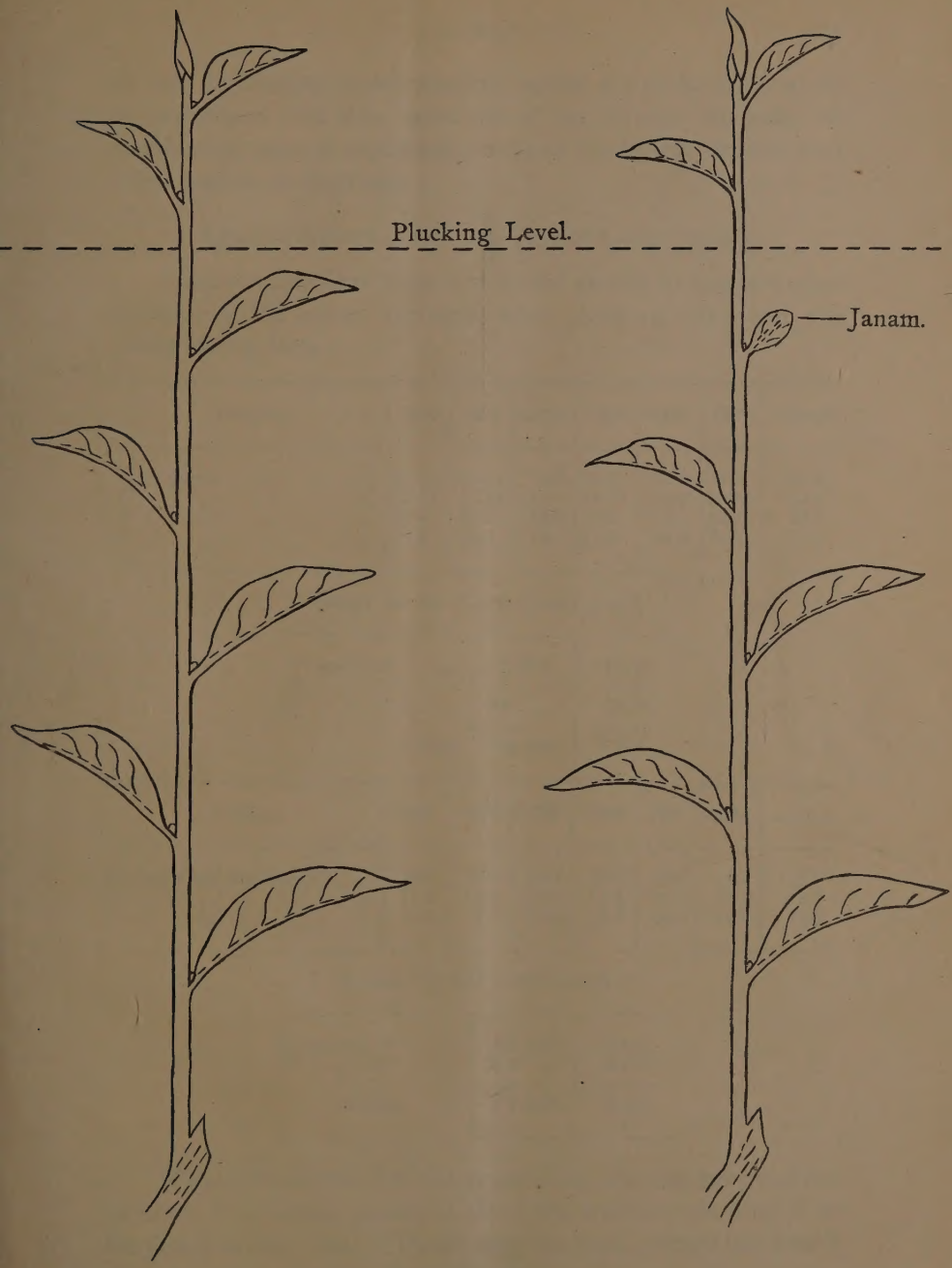
In all three cases, whether plucking over initial growth of 4″, 6″ or 8″, leaving a leaf on the second flush causes a loss in crop of about 9% for three years, but after that there is relative improvement of the bushes on which a leaf is left, till in the sixth year of plucking, crops are about equal or slightly greater where the leaf has been left.

Bushes are tipped accurately at the height specified, usually leaving a short length of stalk above the highest leaf. Where bushes are subsequently plucked to the janam, this short length of stalk usually dies back as far as the highest leaf. Where a big leaf is subsequently left, this short length of stalk nearly always remains green to the end of the season, which difference may be another indication of increased vigour.

After six years, more definite gains from leaving a leaf might be expected.

This particular tea was last cut to 20″ in the cold weather 1920-21 and is now so high (particularly where much growth is left) that plucking is becoming slow, and is losing in accuracy. It has been cut back to 22″ this cold weather. Next year, when all are plucked alike, the increased vigour due to previous more sparing plucking may show up in relative crop.

Following the usual procedure it is proposed to give 12″ growth before tipping in 1933, and 10″ in 1934, on all lines, after which the previous styles of plucking will be resumed. It will



Primary shoot plucked

Primary shoot plucked over Janam.

be very interesting to see whether bushes are so far restored by this treatment that they again stand the harder plucking, or whether the present slight superiority of the bushes plucked over a leaf persists or increases.

Effect of difference in initial growth before tipping.

Here we have four lengths of initial growth to compare when plucking to the janam, and three when plucking over a leaf, the yields having been :—

Plucking	1927	1928	1929	1930	1931	1932	average
4″ to janam	13·3	13·5	14·9	14·6	17·5	14·4	15·2
6″ ,, ,, ...	13 15	12·45	14·0	14·05	16·3	13·55	13·9
8″ ,, ,, ...	12 9	11·5	13·5	12·5	14·4	12·2	12·8
10″ ,, ,, ...	11 6	10·3	12·7	11·5	14·6	11·6	12·0

average loss for 2″ extra initial growth

6″ against 4″ ...	1·3 mds.	8·5%
8″ ,, 6″ ...	1 1 ,,	8 0%
10″ ,, 8″ ...	0·8 ,,	6·2%
average	1·04 mds.	7·6%

Plucking	1927	1928	1929	1930	1931	1932	average
4″ then 1 leaf then janam ...	12·2	12·0	13·4	14·0	16·5	14·3	13·7
6″ ,, ,, ,, ,, ,, ...	11·9	11·3	12·8	13·3	15·8	13·8	13·1
8″ ,, ,, ,, ,, ,, ...	11·8	9·7	12·5	12·2	14·2	12·5	12·3

average loss for 2″ initial growth

6″ against 4″ ...	0·6 mds.	4·4%
8″ ,, 6″ ...	0·8 ,,	6·1%
average ...	0·7 mds.	5·3%

Within the accuracy of the experiment, the loss from leaving an extra 2″ of initial growth is about 6% whether plucking is to the janam or over a leaf. This is about the same average loss over 6 years as occurs from leaving a big leaf.

In the table below, the yields from plucking at 6″ are taken as the standards for comparison because being averages of 16 lines, they are more accurate than averages of the 4 lines used for the 4″ pluckings.

Plucking	Relative Yields					
	1927	1928	1929	1930	1931	1932
4″ to janam	101	108	107	104	107	107
6″ ,, ,, ...	100	100	100	100	100	100
8″ ,, ,, ...	98	92	96	89	88	90
10″ ,, ,, ...	89	83	91	82	89	85
4″ then 1 leaf then janam ...	103	106	105	106	105	104
6″ ,, ,, ,, ,, ,, ...	100	100	100	100	100	100
8″ ,, ,, ,, ,, ,, ...	99	86	98	92	90	90

In none of the above cases is there any relative improvement, with time, of the bushes on which longer initial growth is left. In fact, losses in the last three years are rather greater than in the first three years.

This is a remarkable and unexpected result. The more lightly plucked bushes have stouter frames, greater spread, and are in altogether better condition. From their appearance it would seem certain that they must yield more, but there has been no reflection of this improvement, in yield to-date. There can be little doubt that had the bushes been plucked to say 6″ after several years of plucking to 8″ or 10″, they would then have yielded more than bushes always plucked to 6″; but it appears that if the leaving of long initial growth continue it will be a very long time before the improvement in the bushes shows in improved yields.

It is, however, very probable that the improvement in the bushes may show next year when all bushes are plucked alike after cutting back.

Time of loss of crop from sparing plucking.

The part of the season during which losses from sparing plucking occur, is a matter of great interest, for which reason monthly crops are given in Tables II and III.

Losses from leaving longer initial growth.

Table II shows monthly crops over 6 years from plucking at different heights from the pruning, and then going to the *janam*. Results from leaving different lengths of initial growth, and then leaving a leaf, show very similar differences and need not be quoted in detail.

When leaving longer initial growth, the greatest part of the loss is made before the second flush comes through near the end of May. This loss, being mainly tippings of poorer quality than average is not of very great account, though the average loss of of crop to the end of May amounts to about 2½% of the crop for the season for each 2″ extra growth left.

The loss in the last week of May, and the remainder of the loss, however is of great importance, falling as it does almost entirely on the second flush teas, which generally are the teas on which the greatest reliance is placed to bring up average prices. For each 2″ extra growth left, the loss of second flush crop has averaged nearly 3% of the total crop for the season. This may seem small, but it represents about 12% of the valuable second flush teas. In good seasons when early growth is rapid, and plucking surfaces are soon formed, the loss may be small, as it was in 1927 and 1929; but in years of bad start when not only are there less second flush teas on the market, but probably they are also intrinsically better, on account of "green-fly stunt", the losses of second flush teas may be very great. For example the loss (per 2″ longer initial growth) of really good late May, June, and earlier July teas is estimated at 21% in 1928 and 15% in 1932 from these particular plots where the "green-fly stunt" happened to be very bad in these years.

Generally speaking, losses of crop from leaving longer initial growth are practically negligible after the third flush comes through after mid-July, but in some years, *e.g.*, 1928 after a very bad start to the season, and 1930 after a serious drought in July, losses may be significant in August.

Losses from leaving a leaf on the second flush.

Table III shows in detail the monthly crops for the first three years of the experiment. After that, as already explained, bushes began to improve from the leaving of the leaf and losses became less till they practically vanished in 1932, the sixth year of the experiment.

Whether a leaf is afterwards left or not, plucking is of course the same till the secondary shoots come through. Yields therefore are the same until about the last week in May, so that totals till the end of May are practically the same whether a leaf be left or not.

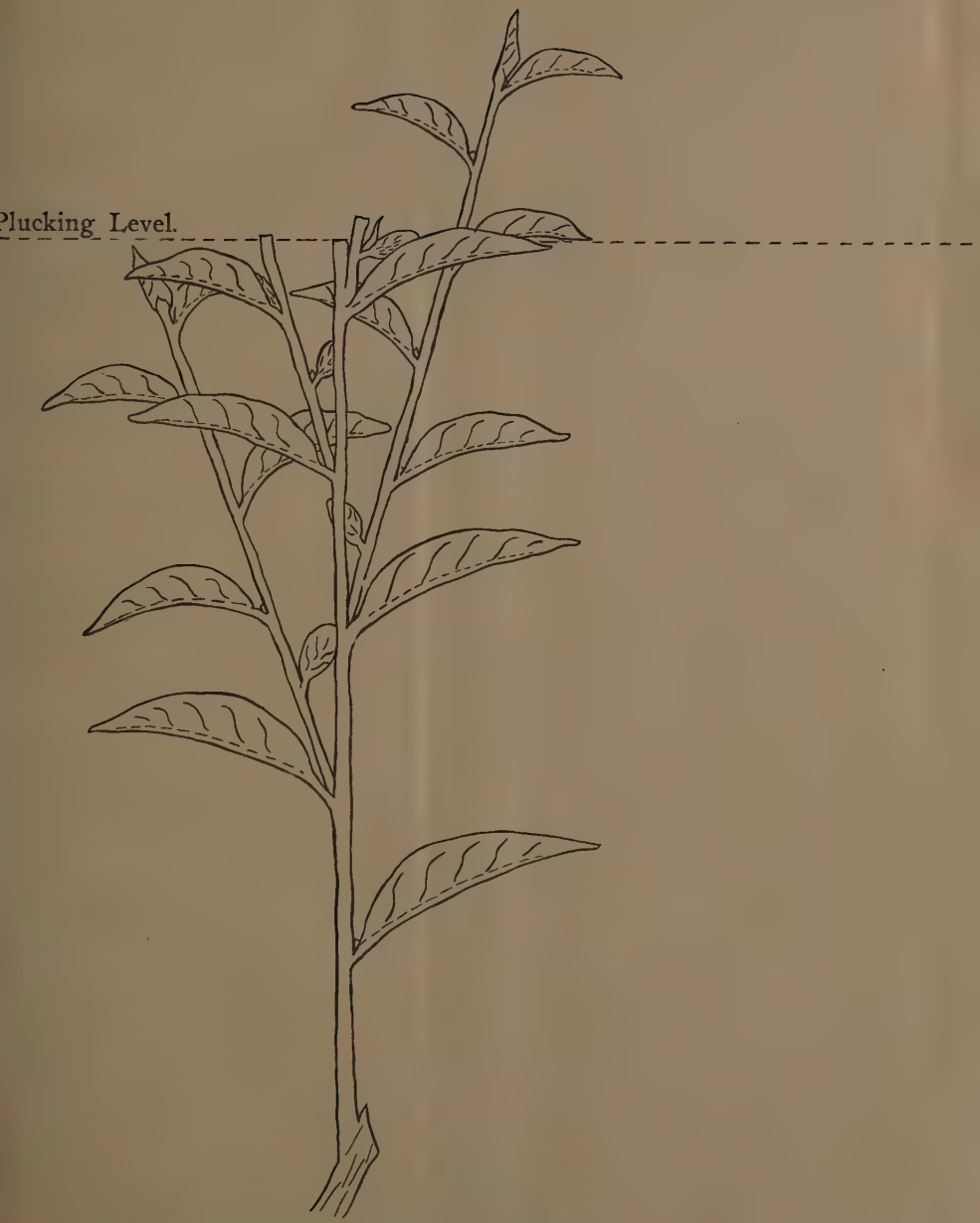
The crop to this date is not all tippings of primary shoots;* some secondary shoots have already been taken. The time of the "second flush" does roughly correspond to the time when the majority of the shoots taken are secondary shoots from the axils of the leaves left after tipping the primary shoots; but the beginning of the "second flush" is a *season* of rapid spring growth which is the same for tea however it is plucked, is the same for unpruned tea as for pruned tea, and is even the same for seed bushes never plucked or pruned, as the Botanist has shown. Tea plucked over long growth still gives an increase in crop over the end of May and early June season, although no secondary shoots may be plucked. Even then, however, very nice plump shoots with fat long buds are taken, above banjhi leaves on the primary shoots, and appear to make tea of quality equal to that from secondary shoots at the same season, although the tippings taken from long primary shoots before they have gone *banjhi* certainly make poor teas.

When the actual first secondary shoots do come through, there is again not very much loss from leaving a leaf. The Botanist has shown that it takes at this time only about four days longer to grow three leaves than to grow two leaves, and many shoots

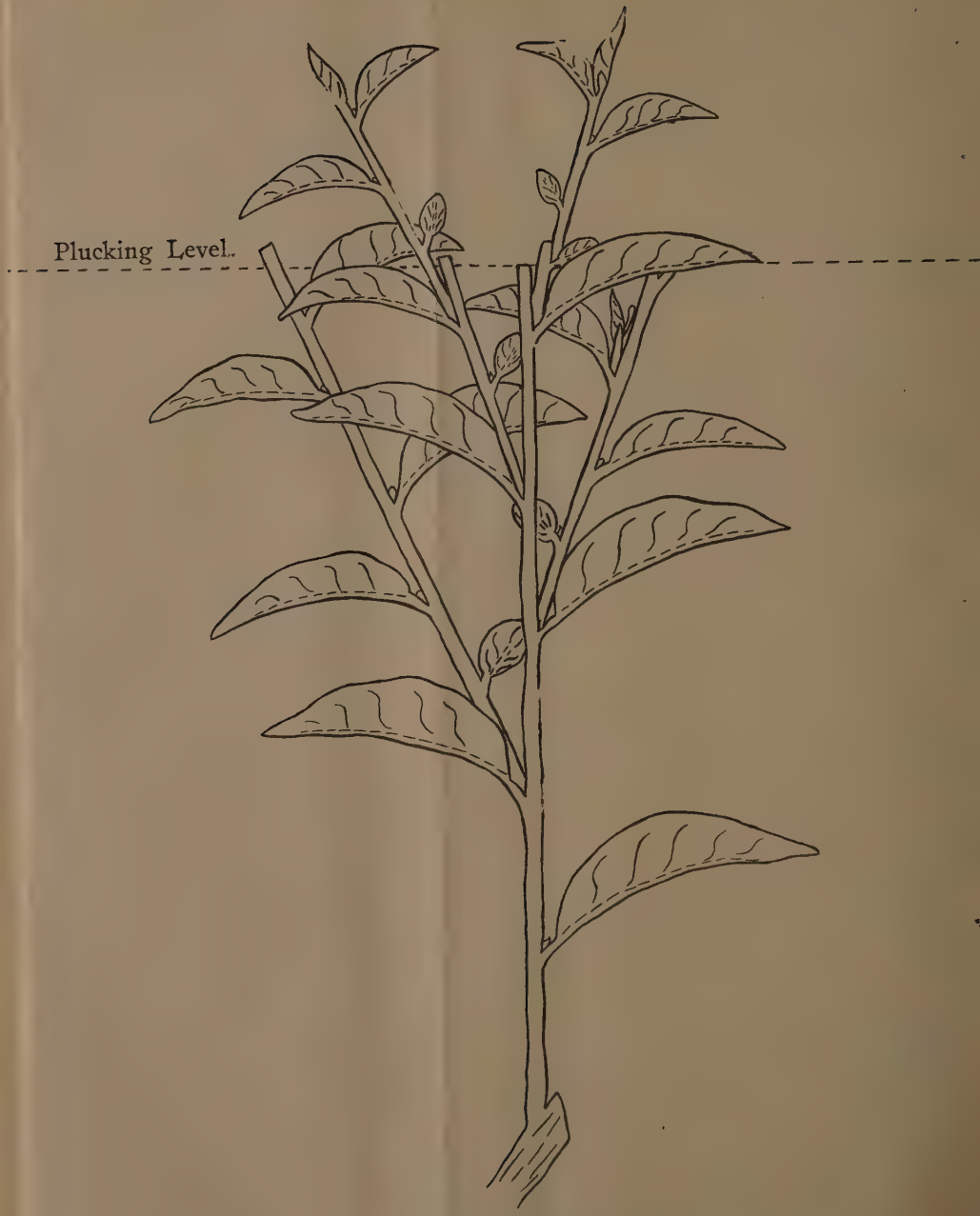
* See Table IV, page 178.

First secondary shoot plucked.

Second secondary shoot plucked.



Third secondary shoot plucked.



Tertiaries plucked.

of one and a bud left at one plucking will be shoots of three leaves in seven days' time; so that on those shoots it makes no immediate difference to crop whether two leaves are taken and the third broken back, or two leaves are taken and the third left on the bush. There is, of course, some loss of late May and early June crop from leaving the leaf; but there is commonly a greater loss in late June and early July, and in years when the "green-fly stunt" is bad and persistent these teas often appear to be quite as valuable as those of the peak of the second flush. Leaving a leaf, therefore, also loses tea at a season of good quality; and, again, the more valuable the season makes the teas, the greater is the loss. In 1928 the loss of the "green-fly" tea from leaving a leaf on these plots is estimated at 28%.

There are losses also in August and September, which, though of poorer teas, count significantly in reducing the crop for the season.

Results in the Dooars.

Experiments at Tulsipara, in the Dooars, extending so far over two years, have produced similar results. Those for 1932 may be quoted.

These results were obtained in the presence of mosquito blight, not very severe till late in 1932, but very serious throughout 1931, practically shutting up the bushes after July: yet the hard plucking still pays.

It remains to be seen how long such results can be maintained.

Style of Plucking	mds. tea per acre to end October
1. 6″ to janam	8·83
2. 8″ to janam	7·73
3. 6″ then 1 leaf then janam	7·88
4. 8″ then 1 leaf then janam	7·18
5. 4″ then 1 leaf throughout season	7·12

The times during which losses are made are of interest and can be seen in Table V. below :—

TABLE V.

monthly crops in lbs. leaf per 1400 bushes, Tulsipara, 1932.

(seven plots of 200 bushes).

	to end April	May	June	July	Aug.	Sept.	Oct.
1. 6″ to janam	26	155	278	262	303	459	252
2. 8″ ,, ,, ...	25	112	232	232	279	424	229
3. 6″ then 1 leaf	24	118	247	198	284	444	231
4. 8″ ,, ,, ,, ...	24	91	216	196	258	438	198
5. 4″ ,, ,, ,, ...	37	148	242	201	204	359	176

At Tulsipara the second flush began to come through with the plucking of May 19th. and a big crop was taken on May 26th. crops being very small until then; hence the May figures are greatly affected by the style of plucking. The tea went banjhi generally before reaching the 6″ measure, hence it makes little difference to the quantity of early tippings whether plucking was to 6″ or 8″ but tipping at 4″ caught very many shoots before they went *banjhi*. On this set of plots (tipped at 4″ then a big leaf left throughout season) the effect of leaving the leaf shows very strongly in late season's crops, and in spite of this very sparing plucking, mosquito attack appears to be no less than on harder plucked plots.

In this season of bad start, as at Borbhetta, any system of sparing plucking loses crop heavily on second flush teas, but also persists late in the season.

Discussion of Results.

The temptations are strong both to pluck over short initial growth, and to go straight to the janam after doing so. These experiments have shown that it has paid to do so over a period of six years. After six years it is certain that the more lightly plucked bushes looked better than the harder plucked bushes; but only the future history of these plots can show whether the

harder plucked bushes will show any permanent deterioration. Experience is quite commonly against hard plucking. Many gardens have produced big crops of fine tea over long periods by plucking at 6″ to the janam; yet others, particularly in climates less favourable to tea, appear to have suffered from the same practice.

Why this difference?

Guessing on such matters is dangerous. The present writer guessed in 1928 * that to leave longer initial growth would "spare" bushes more than leaving a leaf: but these experiments have shown that where a leaf was left the bushes showed a relative improvement in crop after three years, and where longer initial growth was left there has been no relative improvement in crop after six years.

Yet it is necessary to form some hypothesis to be tested by experiment and experience. It appears that some bushes, on some soils, in some climates, stand hard plucking for long periods, while others do not. It seems probable that the difference lies largely in the food supply. Harder plucking, like earlier pruning, really amounts to forcing the bush to yield fully over a longer period of the year. If the food supply is adequate for the crop taken, and the bush is vigorous, has a well developed root system, and is sufficiently well grown to carry a full plucking surface, then it is suggested that it fairly may be required to bear a full crop.

In the case of mature bushes, after the virgin richness of the soil is exhausted, it may be taken as a rough average that about 6 mds. per acre can be maintained if no manure is used. Such bushes will respond to the stimulus of hard plucking and yield more for a time; but the hypothesis suggested is, that if even seven maunds are taken from bushes fed to give six maunds, then the difference must come out of the reserves in the bush, with consequent deterioration. The tea at Borbhetta on which the experiments described are performed, gets 40 lbs. nitrogen per acre annually, considered sufficient to maintain permanently about

* *Quarterly Journal* 1928, p. 115, para. 3.

10 mds. per acre, but the tea was planted only in 1919 and the soil's accumulated store of fertility is not yet exhausted. This would have been sufficient to maintain crops of over ten maunds, but probably not as high as the average of 15 mds., taken by plucking at 4″ to the *janam*, or perhaps even the 14 maunds taken by plucking at 6″ to the *janam*, and these bushes have latterly looked somewhat exhausted at the end of a season, although crops have been well maintained over six years. It is feared, therefore, that these hard-plucked bushes may not yield after cutting-back as well as they did before cutting : yet if they continue to yield an average of 10 mds., after say twenty years, it will be considered that bushes have not been unduly pressed, and that the hard plucking has paid in yielding revenue early, instead of deferring dividends.

It is considered therefore that hard-plucking—say at 6″ to the janam—need not be feared on well-fed bushes in good condition, and the convenience, ease, and accuracy of this style of plucking has much to recommend it. Individual bushes, even among good tea, may show signs of being overworked : but it is better to treat such individuals separately than to lose crop from a whole section on their account. It is recommended that such bushes should receive extra manure and be left unplucked for a season.

Once plucking has started it is difficult to get such bushes left unplucked. It is recommended therefore that in order to mark them, they should be left unpruned. Generally, after one year of such treatment, good new shoots of red wood have arisen, and diseased stems can be cut away to leave sound bushes capable of resuming their places in the team. If still unsatisfactory after one season, they may be left unplucked for another season; but our experience at Borbhetta is that a mature bush which does not respond in two seasons, never will do so, and it is replaced, at the annual infilling. The trouble at Borbhetta with such bushes usually is red-rust, and this is commonly the case on many gardens, but certain other diseases may have similar effects necessitating lighter plucking.

When whole sections are believed to require more sparing plucking, the Borbhetta experiments indicate that it is better to spare by leaving a leaf than by leaving longer initial growth. Therefore, in spite of the greater difficulty and inconvenience of this style of plucking, it should be adopted in such cases.

In all cases where sparing plucking is considered advisable, harder plucking should be resumed as soon as bushes appear able to stand it; and it should always be considered whether increased manuring may not pay in enabling the resumption of such harder plucking with its accompanying increase, not only in average yield but in average price.

BAZALONY PLUCKING PLOTS, BORBHETTA

TABLE I.

Yields in mds. tea per acre assuming 100 lbs. green leaf to give 22½ lbs. tea.

Expt.	Set.	Plucking System	All plucked alike		Under different plucking						Total 1927-1932
			1925	1926	1927	1928	1929	1930	1931	1932	
1	1	4″ to janam	10·8	12·5	13·4	13·5	14·9	14·6	17·5	14·4	91·1
2	7	4″ then 1 leaf then janam ...	10·6	12·4	12·2	12·8	13·4	14·0	16·5	14·3	82·4
3	2	6″ to janam	10·7	12·4	13·4	12·1	14·6	14·2	16·9	13·8	85·3
,,	11	6″ ,, ,, ...	10·6	12·5	12·9 13·15	12·1 12·45	13·9 14·0	13·7 14·05	16·1 16·3	13·3 13·55	82·0 83·5
,,	12	6″ ,, ,, ...	10·5	12·3	13·1	12·5	13·4	14·0	15·7	13·2	81·9
,,	13	6″ ,, ,, ...	10·7	12·4	13·2	12·8	14·2	14·3	16·5	13·9	84·9
4	8	6″ then 1 leaf then janam ...	10·8	12·5	11·8	11·5	12·1	12·7	15·6	12 9	76·6
,,	14	6″ ,, ,, ,, ,, ,, ...	10·8	12·5	11·8 11·9	10·8 11·3	13·4 12·8	13·3 13·3	15·6 15·8	14·4 13·85	72·0 78.7
,,	15	6″ ,, ,, ,, ,, ,, ...	10·5	12·4	12·1	11·7	13·0	13·8	16·4	13·7	80·7
,,	16	6″ ,, ,, ,, ,, ,, ...	10·8	12·4	11·8	11·3	12·8	13·3	15·7	13·3	78·5
5	3	8″ to janam	10·8	12·4	12·9	11·5	13·5	12·5	14·4	12·2	76·6
6	9	8″ then 1 leaf then janam ...	10·9	12·5	11·8	9·7	12·5	12·2	14·2	12·5	73·9
7	4	10″ to janam	10·8	12·4	11·6	10·3	12·7	11·5	14·6	11·6	72·3
8	10	3 leaves then 2 leaves then 1 leaf	10·8	12·5	12·4	10·0	13·4	12·2	12·6	13·0	72·8
9	5	6″ then 8″ to janam ...	10·6	12·3	11·5	11·0	12·6	13·0	15·4	12·1	76·2
10	6	4″ then 6″ then 8″ then janam ...	10·6	12·3	12·8	11·0	15·4	14·8	16·3	13·1	83·1

Table II.

Time of loss of crop from leaving longer initial growth. Monthly crops in lbs. leaf per 320 bushes from plucking at different initial lengths of growth.

	to end May	June	July	Aug.	Sept.	Oct.	Nov.	Total
1927								
4″ to janam ..	32	98	124	113	174	135	80	756
6″ ,, ,, ...	23	98	120	115	173	138	79	746
8″ ,, ,, ...	17	97	112	113	173	138	84	734
10″ ,, ,, ...	10	69	91	111	164	136	80	666
1928								
4″ to janam ...	39	76	101	138	158	185	69	766
6″ ,, ,, ...	22	66	85	135	148	183	66	705
8″ ,, ,, ...	11	52	69	123	146	186	63	640
10″ ,, ,, ...	5	35	56	108	139	177	64	584
1929								
4″ to janam ...	87	101	110	174	149	142	78	841
6″ ,, ,, ...	54	101	108	171	137	142	79	792
8″ ,, ,, ...	39	90	102	168	149	140	76	764
10″ ,, ,, ...	24	77	91	163	149	137	79	720
1930								
4″ to janam ...	96	81	84	171	145	197	51	825
6″ ,, ,, ...	62	83	82	170	150	196	49	792
8″ ,, ,, ...	38	73	71	150	144	180	49	705
10″ ,, ,, ...	24	59	59	111	135	175	47	610
1931								
4″ to janam ...	118	107	163	145	164	200	97	970
6″ ,, ,, ...	83	94	156	143	170	196	81	923
8″ ,, ,, ...	48	77	140	136	162	173	78	814
10″ ,, ,, ...	34	79	125	134	169	201	84	826
1932								
4″ to janam ...	48	84	122	252	222	137	50°	815
6″ ,, ,, ...	29	74	119	143	210	137	54°	766
8″ ,, ,, ...	14	61	88	143	195	136	55°	692
10″ ,, ,, ...	10	47	79	142	188	133	57°	656

* Plucked till 11th. November only : then cut back.

TABLE III.

Effect of leaving a leaf on time of crop.
Monthly yields in lbs. green leaf per 320 bushes.

	to end May	June	July	Aug.	Sept.	Oct.	Nov.
1927							
4″ then janam	32	92	124	112	175	136	79
4″ then 1 leaf then janam ...	31	89	103	92	172	137	79
6″ then janam	24	99	120	115	196	113	79
6″ then 1 leaf then janam ...	24	84	80	99	169	127	80
8″ then janam	17	97	111	114	170	137	84
8″ then 1 leaf then janam ...	17	83	91	103	173	130	78
1928							
4″ then janam	39	76	101	138	158	185	69
4″ then 1 leaf then janam ...	39	60	68	139	132	186	65
6″ then janam	22	66	85	135	148	183	66
6″ then 1 leaf then janam ...	21	51	62	135	130	179	63
8″ then janam	11	52	69	123	146	186	63
8″ then 1 leaf then janam ...	9	53	37	124	106	173	59
1929							
4″ to janam	87	101	110	174	149	142	78
4″ then 1 leaf then janam ...	81	81	106	153	129	132	76
6″ to janam	54	101	108	171	137	142	79
6″ then 1 leaf then janam ...	49	87	101	152	127	137	74
8″ to janam	39	129	102	168	149	140	76
8″ then 1 leaf then janam ...	35	122	98	150	129	135	72

TABLE IV.

Percentage of shoots of different kinds plucked at different dates, 1932. Plucking at 8″ to janam. Counts made on bushes.*

kind of shoot plucked	May 11	May 18	May 25	June 1	June 8	June 15	June 22	June 29	July 6
Primary shoots ...	92	80	63	37	26	14	9	5	3
1st secondary shoots	8	20	28	42	42	33	36	27	21
2nd " "	0	0	7	17	23	24	25	16	11
3rd " "	0	0	2	4	9	19	17	12	5
4th " " (with a few fifth	0	0	0	0	0·1	8	19	11	3
tertiary shoots ...	0	0	0	0	0	3	4	29	57
crop taken mds. green leaf per acre	·08	·16	·28	·80	1·44	1·40	1·28	1·22	1·04

*See diagrams facing pages 166, 170 and 171.

PRUNING EXPERIMENTS II

BY

H. R. COOPER

Experiments on Cleaning out.

1. *The Tingamira 3-acre block at Borbhetta.*

The same block of Tingamira tea, described in the last number of the Quarterly Journal, included two sets of seven plots each, not cleaned out, which can be compared, respectively, with sets of plots pruned at the same time, and in the same way, except that they were cleaned out.

The results over four years are given in Tables 1 and 2.

It will be observed that with December pruning losses from failure to clean out, were almost negligible in 1929 and 1930, but were very significantly great in 1931 and 1932. Several factors probably contributed towards the differences in the effect of cleaning out in the four years. The tea used had been collar pruned in 1924, unpruned in 1925, and cut to 8″ in 1926. In 1927 serious attack by rim-blight and red rust produced a lot of die-back with consequent very clean pruning in 1927. In 1928 also the tea was pruned very cleanly and with "spacing out". In 1929 pruning was at 18″ from the ground, on very clean young bushes, and there was actually little to clean out. In 1930 pruning was at 20″ from the ground, removing about 12″ of growth : again there was not very much to be cleaned out.

Both 1929 and 1930 were years of good start : although conditions were bad for growth in June, and particularly July, 1930, red spider and leaf diseases were not serious early in either season.

1931 was a year of spring drought, although conditions became very favourable for growth later. Red spider and leaf diseases were fairly bad generally, but very much worse on the plots not cleaned out.

The season 1932 was one of very bad start and the annually pruned tea suffered very badly, when not cleaned out for the fourth year in succession. The loss from failure to clean out was significant at every plucking throughout the season; but the greatest loss was again in the early part of the season when red spider and the "green-fly" stunt were restricting growth seriously.

Losses from failure to clean out annually pruned tea.

	1931	1932
loss to end July	24 per cent	32 per cent
loss in August and September ...	16 ,, ,,	18 ,, ,,
loss in October and November ...	10 ,, ,,	13 ,, ,,

Losses from failure to clean out therefore fall most heavily on the best teas.

General experience, in Assam at any rate, indicates that quality of the earlier teas also is better from moderately cleaned out tea, than from tea not cleaned out.

The tea not-cleaned-out comes away very unevenly, a few vigorous shoots (generally in bunches) get away, and the balance remain *banjhi* for a long time. Cleaned out tea comes away much more evenly, and the less leafy bushes appear more liable to the quality-producing "green-fly" stunt.

So far as annual pruning is concerned, then, cleaning out to a sufficient degree appears to be a necessity, but results of these experiments in 1929 and 1930 indicate that loss from neglect of cleaning out may sometimes be negligibly slight, and in general omission of cleaning out for one year in three would be expected to lead to little loss. In years of very bad start however, when red spider is bad, neglect of cleaning out even for one year, probably reduces, significantly, crops from pruned tea.

In the case of the tea pruned in April, losses also were negligible in 1929 and 1930. These plots were pruned at a time when bushes were growing and the leaving of more leaf undoubtedly

allowed the bushes to make better use of the food present in the soil : crops soon after pruning were slightly greater from the tea not cleaned out, but this slight advantage was afterwards lost, probably on account of the presence of more *banjhi* shoots.

In 1931, when both those cleaned out and those not cleaned out in 1930 were left unpruned, the plots which had been cleaned out yielded the better throughout the season. Those not cleaned out had distinctly the more leaf disease, including some thread blight which was absent from the cleaned-out bushes. About the same difference continued during the early part of 1932 when both continued to be plucked unpruned till April 14th., after which they were pruned; those of Experiment 3 again with cleaning out, and these of Experiment 4 by merely cutting across at the same height. When this latter was pruned it contained quite a lot of dead twigs, but few living *banjhi* twigs remained below the pruning level, and the remaining shoots were stout and healthy. The bushes had, in this way, cleaned themselves out, though the dead twigs remain a danger. Again the leaving of more leaf on the bushes when pruning during the growing season allowed more rapid early growth. The bushes not cleaned out had to be tipped two weeks earlier than those cleaned out; following crops were distinctly better till about the middle of August, and were slightly the better till about the end of September, after which they were slightly worse than from bushes cleaned out.

The crops in lbs. green leaf per 630 bushes in 1932, were :—

	before pruning till 14th April	after pruning		
		till August 15th	August 15th to September 29th	October 6th to November 24th
cleaned out ...	186	78	191	284
not cleaned out ...	169	94	198	269

At Borbhetta, then, it paid on the unpruned tea in 1931 to have cleaned out when pruning on one-year wood in the previous April of 1930, but the cleaning out of April 1932 on tea previously

unpruned gave a negligible increase in total crop in the year of pruning, 1932, and a small loss in the crop obtained after pruning.

II. Experiments at Tulsipara

Similar experiments at Tulsipara (Dooars) have been carried out over two years, in the case of December pruning only.

The following crops were obtained in lbs. green leaf per 1400 bushes.

Pruned in both years.

1931

	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
cleaned out	2	62	144	151	143	58	37	11	3	611
not cleaned out ...	1	39	104	152	182	111	83	36	8	716

1932

cleaned out	11	27	188	127	169	346	312	243	30	1453
not cleaned out ...	3	6	86	112	157	362	322	277	50	1375

In both years the loss of early crop from failure to clean out was great : but later in both seasons the tea not cleaned out yielded the better. It may be coincidence, but in each season the change in relative yield occurred at about the time when mosquito blight attack began to be severe, and observation made it clear that the bushes not cleaned out were less damaged by mosquito blight, probably because the following attacks by fungus diseases of stem and leaf were less.

Early in the season, *e.g.*, early June 1931, the cleaned-out bushes looked just as similarly treated bushes do in Assam, with a good number of stout green flushing shoots evenly distributed over the bush. At this time the bushes not cleaned-out carried

a smaller number of thinner, more woody shoots, in bunches mainly near the centre, and there was a mass of *banjhi* growth inches below the plucking surface.

By September after mosquito blight attack had been severe, it was quite clear that these latter bushes, poor as they looked, were suffering less than the better-looking cleaned-out bushes. This difference cannot be explained, but perhaps it depends upon the large area of unattacked hard mature leaf below the surface of the bushes not cleaned-out, which keep the bush fed; while the softer leaf of the cleaned-out bushes is destroyed by fungus diseases following mosquito blight attack.

In 1931, when mosquito blight attack was early and very virulent, the bushes not cleaned out yielded the better from near the end of June and gave a bigger total crop for the season. In 1932, when attack was not severe till late in the season, the cleaned out bushes yielded the better till August, and did not lose very much later in the season, so that in 1932 the cleaned out bushes yielded a total of about 5% more than the bushes not cleaned out.

It may be assumed that in the absence of Mosquito blight it would pay to clean out in the Dooars as it does in Assam. In the presence of Mosquito blight the position is more doubtful. Probably cleaning out would pay in good years, but (particularly having regard to its greater cost) not in bad years. Possibly, maximum crop would be obtained by cleaning out, and spraying with lime-sulphur to reduce the damage by mosquito-blight, and particularly to reduce the attack on leaf and stem by the following fungus diseases. In the absence of spraying, the Tulsipara experiments must be continued for many years, before it can be seen whether it pays, on the average, to clean out on gardens liable to severe mosquito blight.

Experiments also were made at Tulsipara with more severe cleaning out. Two further sets of seven plots (each plot containing 200 bushes) were stick pruned and lightly centred before the 1931 season. Before the 1932 season one of these sets was pruned with light cleaning out, the other was left unpruned.

The monthly yields obtained are shown below in lbs. green leaf per 1400 bushes. Yields from the ordinary light cleaning out are given for comparison.

1931

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Total
ordinary clean-pruning	62	144	151	143	58	37	11	3	611
stick pruning Set 1	35	95	98	103	47	32	7	2	419
stick pruning Set 2	29	89	93	108	51	27	8	2	407

1932

both moderately cleaned out.

ordinary clean-pruning in 1931	38	188	127	169	346	312	243	30	1453
stick-pruning in 1931 ...	32	142	102	136	273	252	197	27	1162

1932

both unpruned

ordinary clean-pruning in 1931	174	218	152	204	369	308	226	36	1687
stick-pruning in 1931 ...	167	184	125	179	331	272	201	23	1482

It will be observed that the effect of the very severe cleaning out is a big loss, not only in the year of pruning, but also in the following year, whether the tea is pruned or not.

These losses probably are more marked in the presence of mosquito blight, but it is believed (no exact experiments on the point are recorded) that similar losses would be made, from over severe cleaning out, in Assam or the Surma Valley.

The most striking feature of the appearance of the bushes is the lesser width of those which were severely cleaned out. The bushes so "emptied", filled up the spaces to a large extent with in-growing shoots from the outsides. The presence of central shoots seems necessary to force growth outwards.

Cleaning-out therefore must not be more severe than is necessary. It appears necessary (at least in the absence of mosquito blight) to remove *banjhi,* weak and diseased shoots, and dead wood, but any reduction of the number of good healthy shoots appears undesirable, although to avoid future trouble it is sound not to allow the growth of branches or shoots which are actually touching, or so close that they may be rubbed together by wind.

Effect of time of cleaning-out.

As explained in the former note on results of pruning experiments,* it has been suggested that in order to get full value of the advantage of early pruning, a garden might be first pruned by merely cutting across at the desired height, without spending time on cleaning out, while cleaning out should follow at a second operation. It is important to have some measure of the influence of the time interval between cutting across and cleaning. Unfortunately no large area of tea is available at Borbhetta for such experiments ; but an experiment on a small scale was tried there on the difference made by cleaning out immediately after cutting across, as against cleaning out considerably later.

Six adjoining plots of 90 bushes each, all treated alike since planting in 1922, had yielding in 1930 and 1931 as below :—

Yields in lbs. green leaf per plot.

set 1				set 2			
	1930	1931	Total		1930	1931	Total
plot 248 b ...	84	87	171	plot 248 c ...	89	84	173
,, ,, d ...	97	98	195	,, ,, e ...	97	97	194
,, ,, f ...	92	98	190	,, ,, g ...	96	98	195
Total	273	283	556	Total	282	279	562

These provided three pairs of adjoining plots, of identical previous treatment since planting, and very closely alike in appearance and in yield.

* Quarterly Journal, 1932, part III, p. 147.

In late December, 1931, all six were cut-across, without cleaning out, on the same day. Set 1 were cleaned out on January 4th. 1932. Set 2 were cleaned out on February 25th. 1932. On February 25th., there was considerably growth on the *banjhi* twigs which had been left at the first cutting across, and the "empty" appearance of these late-cleaned-out bushes was very marked until about the end of July; yet they yielded no less during this part of the season, yields being, in lbs. green leaf per 270 bushes.

	set 1	set 2
	cleaned out Jan. 4th.	cleaned out Febr. 25th.
to end May	10 lbs. 13 ozs.	10 lbs. 12 ozs
,, June	31 ,, 11 ,,	32 ,, 12 ,,
,, July	27 ,, 12 ,,	29 ,, 7 ,,
,, August ...	69 ,, 8 ,,	68 ,, 13 ,,
,, September ...	67 ,, 4 ,,	61 ,, 0 ,,
,, October ...	57 ,, 7 ,,	58 ,, 3 ,,
,, November ...	37 ,, 0 ,,	35 ,, 11 ,,
Total	302 lbs. 7 ozs.	296 lbs. 10 ozs.

In total crop the individual pairs compare as below :—

	cleaned out Jan. 4th.		cleaned out Feb. 25th.
plot 248 b	98 lbs. 4 ozs.	plot 248 c	90 lbs. 9 ozs.
,, ,, d	108 ,, 10 ,,	,, ,, e	102 ,, 7 ,,
,, ,, f	95 ,, 9 ,,	,, ,, g	103 ,, 10 ,,
Total	302 ,, 7 ,,	Total	296 ,, 10 ,,

There is only about 2% difference in total yield for the season, and the monthly yields, with the exception of those for September, are as nearly equal as can be expected from an experiment on this scale.

It may be assumed therefore that a difference of 52 days in the date of cleaning out makes at any rate very little difference

to crop in the following season, and in practice the interval between cutting across and cleaning out would seldom be as great as 52 days.

Summary

Cleaning out, in Assam, generally makes a considerable difference for the better in total crop, and particularly in early crop. The difference increases as the tea is left longer without cleaning out. Bushes already very clean from past pruning, or from having been left unpruned, generally lose little from neglect of cleaning out for one year. In the Dooars when attacked by mosquito blight, bushes not cleaned out have better resisted the effects of the attack, and hence show better crops late in the season : so that over two years there has been no profit from cleaning out, although early crops are improved by cleaning out as they are in Assam.

Experiment in the Dooars has shown very great loss from excessive cleaning out, and it is believed that similar though probably smaller losses would be found in Assam.

It is recommended therefore that cleaning-out should be confined to the removal of *banjhi* shoots, weak or deseased shoots, and dead wood ; all strong shoots which are not likely to interfere with each other being left.

It has been shown that delay in cleaning out, after cutting across without cleaning out, has little effect on crop.

TABLE I.

Yields in lbs. green leaf per 630 bushes (.254 acres) (Borbhetta)

Expt.	Set	Yields under same treatment			Treatment 1929 to 1932	Yields under different treatment				Total 1929 to 1932	equal to total mds. tea per acre taking made tea as 22½% of green leaf.
		1926	1927	1928		1929	1930	1931	1932		
1	1	409	295	563	clean pruned December annually	791	919	1199	1181	4090	45.4
2	5	407	288	563	cut across December annually	759	889	999	937	3586	38.8
3	4	408	280	565	clean pruned April, 1929, 1930, 1932, unpruned 1931	564	552	1075	749	2931	32.5
4	6	421	296	561	cut across April 1929, 1930, 1932 unpruned 1931	548	552	946	731	2777	30.9

TABLE II.

Loss per cent from failure to clean out (Borbhetta).

	1929	1930	1931	1932
December pruning	4·0	3·3	16·7	20·7
April pruning	2·9	0	12·0	1·2

THE ACIDITY OF TEA SOILS OF NORTH EAST INDIA

Part III. *The Effect of Manures on Soil Acidity.*

BY

C. J. Harrison

The use of lime in various forms for the purpose of decreasing soil acidity, and of sulphur for achieving the opposite effect have been dealt with in previous publications in this Journal, and it is not the purpose of this article to deal further with the effect of these two fertilisers.

The present intention is to demonstrate the influence on soil acidity of the more commonly used manures, in particular those supplying nitrogen. These may be divided into two classes, organic and inorganic. Of the former class cattle manure, oilcake blood meal and fish meals and leguminous crops; and of the latter, sulphate of ammonia, chloride of ammonia, calcium cyanamide, nitrate of soda and nitrate of potash, have been studied.

The soil on which these experiments have been carried out is a sandy one, typical of large areas of Assam, and the effects observed should therefore be applicable to a fairly large proportion of the tea land in North India. No experiments have been done on stiff soils, or on soils rich in organic matter, but from a knowledge gained by laboratory tests of the comparative response of various types of soil to treatment for varying their acidities one can safely make the generalisation that for soils with normal acidities the greater the clay or organic matter content, the smaller will be the effect of manures on the soil acidity.

Soil acidities have been determined from time to time on the various plots comprising six experiments on the manuring of tea at Borbhetta. Results from each of these experiments are given in detail.

1. *The Matelli Experiment. Series 1.*

This comprises 18 plots on which there are six treatments, each treatment being in triplicate. Acidities were determined in 1928 after 7 years of treatment, which consisted in the application of various forms of nitrogenous manure in quantities to give 30 lbs. per acre of nitrogen. This was accompanied by potash and phosphatic manures supplying 30 lbs. per acre each of potash and phosphoric acid. The table below gives the lime requirement (Hopkins acidity), the pH of a water extract of the soil, and the pH of a neutral salt extract (normal potassium nitrate solution) of the soil.

TABLE I.

Acidities of Matelli Experiment (Series 1) Plots.

Treatment	lime requirement in lbs. lime per million lbs. soil	pH of soil water extract	pH of neutral salt extract
check plots ...	497	5·67	4·10
sulphate of ammonia ...	674	5·23	3·97
nitrate of soda ...	488	5·93	4·13
oil cake ...	427	5.67	4·20
boga medeloa cuttings ...	415	5·70	4·20
animal sinews ...	434	5·57	4·13

The only significant change in Hopkins acidity is the increase due to sulphate of ammonia, which has also decreased the pH value (increased the acidity) of the soil solution and the neutral salt extract. The change however is comparatively small. In this connection it may be mentioned that the use of phosphate in conjunction with sulphate of ammonia lessens the acidifying effect of the latter manure. Evidence in support of this statement is given later. Thus, had sulphate of ammonia alone been used; its acidifying effect after 7 years of application (even at the low rate of 150 lbs. per acre) would have been greater.

Nitrate of soda has increased the pH of the soil water extract significantly (the actual acidities of the three plots under this

treatment were 6.0, 6.0 and 5.8 as compared with 5.6, 5.7 and 5.7 for the unmanured plots). It has not however changed the pH of the neutral salt extract—an indication of the "reserve" acidity of the soil. The three organic manures have had no significant effect on the soil acidity.

2. *The Matelli Experiment. Series 2.*

This is an extension of the previous experiment and consists of four treatments each in triplicate. As before the nitrogenous manures were applied with potash and phosphate, each manure supplying 30 lbs. per acre of its respective plant food. Table II gives the acidity results obtained after five years of treatment.

TABLE II.

Acidities of Matelli Experiment (Series 2) Plots.

Treatment	lime requirement in lbs. lime per million lbs. soil	pH of soil water extract	pH of neutral salt extract
nil			
check plots	203	5·73	4·63
calcium cyanamide ...	173	5·87	4·83
fish meal	268	5·77	4·50
sterilisd animal meal ...	264	5·77	4·63

Again the organic manures have had no effect on the soil acidity. Calcium cyanamide has reduced the acidity as determined by all three methods, to an appreciable, though not great, extent.

On account of its cheapness and efficiency sulphate of ammonia is used more than any other "chemical manure" in tea, and in view of the fact that it increases soil acidity its effect in this direction has been studied more completely than that of any other manure. In the following experiment its effect on plots which had previously had large dressings of nitrate of soda is interesting.

3. *The Burma Nitrogen Experiment.*

The object of this experiment was to determine the effect on the outturn and quality of tea, of annual applications of a nitrogenous chemical manure in varying quantities.

Soil acidities have been determined several times, but only of a certain number of plots. These plots embrace 8 different manurial treatments out of the 16 treatments included in the experiment. Apart from the check plots, (receiving no manure) there are two groups of treatments. The first group consists of four plots, getting respectively, 30, 60, 90 and 120 lbs. per acre of nitrogen every year, and in addition a dressing of potash and phosphate equal to 30 lbs. per acre of potash and the same amount of phosphoric acid. The second group consists of three plots getting respectively 60, 90 and 120 lbs. per acre of nitrogen and in each case the same amounts of potash and phosphoric acid, as they get of nitrogen. In all cases the manures are put on in divided doses throughout the season, each dose consisting of manure equivalent to 15 lbs. per acre. The nitrogenous manure used from 1924 up till 1928 was nitrate of soda, and from 1929 onwards sulphate of ammonia was used. Sulphate or muriate of potash and ordinary superphosphate supplied the necessary potash and phosphoric acid.

Tables III *a*, *b* and *c*, give the acidity results from these plots determined in 1927 (when nitrate of soda had been used for 4 years); in 1931, after three annual treatments with sulphate of ammonia; and three times during 1932.

TABLE III (*a*).

Hopkins Acidities of Burma Experiment Plots.

Treatment lbs. per acre of			nitrate of soda	sulphate of ammonia			
N.	P.	K.	July 1927	January 1931	March 1932	April 1932	June 1932
0	0	0	658	473	459	319	431
30	30	30	565	403	340	303	368
60	30	30	494	500	477	353	533
90	30	30	494	563	555	455	602
120	30	30	500	612	629	476	659
60	60	60	463	459	466	304	485
90	90	90	470	356	482	339	466
120	120	120	377	522	547	421	613

TABLE III (*b*).

pH of soil water extract of Burma Experiment Plots.

Treatment lbs. per acre of N.	P.	K.	July 1927	January 1931	March 1932	April 1932	June 1932
0	0	0	5·34	5·52	5·47	5·36	5·50
30	30	30	5·34	5·51	5 45	5·19	5·49
60	30	30	5·48	5·30	5·23	5·03	5·24
90	30	30	5·43	5·35	5·12	4·91	5·07
120	30	30	5·40	4·91	4·94	4·52	4·84
60	60	60	5·44	5·37	5·30	5·09	5·39
90	90	90	5·35	5·24	5·14	4·92	5·23
120	120	120	5·42	5·06	4·98	4·62	4·93

TABLE III (*c*).

pH of neutral salt extract of Burma Experiment Plots.

Treatment lbs. per acre of N.	P.	K.	July 1927	January 1931	March 1932	April 1932	June 1932
0	0	0	3.94	4·45	4·34	4·37	4·21
30	30	30	4 04	4·47	4·41	4·42	4·25
60	30	30	4 06	4·38	4·31	4·36	4·18
90	30	30	4·02	4·36	4·24	4 25	4·03
120	30	30	4·02	4·33	4·21	4·21	3·94
60	60	60	4·00	4·46	4·37	4 41	4·18
90	90	90	4·04	4·51	4·29	4·34	4·10
120	120	120	4·05	4·39	4·17	4·22	3·99

There is no indication from the 1927 results, that the nitrate of soda applied annually for 4 years had reduced the Hopkins Acidity or increased the pH of the neutral salt extract. It is possible however that the addition of potash and phosphatic manure (muriate of potash and ordinary superphosphate) has been responsible for a slight reduction in acidity, roughly in proportion to the quantity of these manures applied.

The cumulative effect of application of sulphate of ammonia in 1929, 1930 and 1931, (after nitrate of soda had been applied in 1924, 1925, 1926, 1927 and 1928), has been to increase the acidity, roughly in proportion to the amount of sulphate of ammonia applied. This increase in acidity is reduced by the use of potash and phosphate together with the nitrogenous manure. The results for January 1931 and March 1932 are comparable, being

both obtained before manures had been applied for the particular year, and they serve to indicate that little if any increase in acidity has resulted from the one year's manuring. Differences are small and no correlation appears between the increase in acidity and the quantity of sulphate of ammonia applied in one year only. It is only in the cumulative effect of application over several years that any real difference in acidity due to the manurial treatment shows up.

The difference in acidity in April as compared with March 1932, is not significant, but by June when rain has started the nitrification of the ammonia, an increase in the acidity of the plots receiving heavier doses of manure is apparent.

It is important to note that in no case, even where heavy applications of sulphate of ammonia for 4 years have been made, has the soil acidity been increased to an unduly high figure, and the tea is still maintaining its high yield on these heavily manured plots.

4. *The Mesai Manipuri Experiment.*

The effect on soil acidity of two annual applications of sulphate of ammonia, followed by one application of calcium cyanamide is shown from a study of the acidity of certain of the plots in this experiment.

Acidities were determined before and after sulphate of ammonia treatment in 1930 and 1931, and also before and after treatment with calcium cyanamide in 1932. The results are given in Table IV, *a*, *b* and *c*.

TABLE IV (*a*).

Hopkins acidity of Mesai Manipuri Experiment Plots.

Treatment N.	P.	K.	sulphate of ammonia				calcium cyanamide		
			1930		1931		1932		
			before	after	before	after	before	after	4 months after
0	0	0	768	722	544	531	671	536	733
40	20	20	710	713	564	617	681	387	611
80	40	40	689	476	538	611	772	271	528
120	60	60	756	759	633	581	786	229	520

TABLE IV (*b*).

pH of soil water extract of Mesai Manipuri Experiment Plots.

Treatment N. P. K.	sulphate of ammonia				calcium cyanamide		
	1930		1931		1932		
	before	after	before	after	before	after	4 months after
0 0 0	5·34	5·04	5·25	5·31	5·33	5·26	5·26
40 20 20	5·34	5·96	5·07	4·81	5·26	5·21	5·20
80 40 40	5·36	4·91	5·02	4·67	5·15	5·38	5·26
120 60 60	5·37	4·87	4·92	4·49	5·00	5.45	5·26

TABLE IV (*c*).

pH of neutral salt extract of Mesai Manipuri Experiment Plots.

Treatment N. P. K.	sulphate of ammonia				Calcium cyanamide		
	1930		1931		1932		
	before	after	before	after	before	after	4 months after
0 0 0	4·34	4·26	4·36	4·27	4·26	4·20	4·19
40 20 20	4·36	4·28	4·38	4·24	4·22	4·37	4·25
80 40 40	4·36	4·26	4·35	4·22	4·19	4·54	4·31
120 60 60	4·37	4·23	4·34	4·18	4·18	4·97	4·31

The sulphate of ammonia used in 1930 and 1931, has at the end of two years produced a distinct increase in soil acidity, which is in proportion to the amount of sulphate of ammonia used. As all plots were at about the same acidity before treatment we may consider simply the annual differences in acidity between the check plot and the other treatments.

These differences are, in the first year, only significant in the case of the pH values of the soil solutions. The increases in acidity immediately after, and one year after, application of manures are shown in the table below.

TABLE V.

Increase in acidity (decrease in pH) due to sulphate of ammonia.

lbs. per acre of sulphate of ammonia	1930		1931	
	just after application	one year after application	just after application	one year after application
200	·08	·18	·50	·07
400	·13	·23	·64	·18
600	·17	·33	·82	·33

The big increase in acidity in 1931, just after application is due to the fact that nitrification had set in when the samples were taken and much of the increase may be attributed to the high nitrate content of the soil. By the end of the year this has disappeared.

There has been a small increase in Hopkins acidity after 2 years treatment with sulphate of ammonia, and a small increase in acidity as measured by the pH value of the neutral salt extract.

The effect of calcium cyanamide applied in the third year has been to restore the acidity on manured plots to that of the check plots. Results obtained on soil samples taken just after application of cyanamide show that the acidity has been reduced to a figure considerably below the original value, but this is merely a temporary effect, caused by ammonification of the cyanamide, liberating free ammonia, (which is alkaline), in the soil. By September, when further determinations were done, the ammonia had been nitrified and absorbed by the plant or lost by leaching and the drop in acidity is much less. A similar effect due to free ammonia in the soil occurs with organic manures like cattle manure, and is mentioned later in this article.

It may be concluded that any increase in acidity due to sulphate of ammonia treatment for two successive years can be counteracted by use of the same annual dose of calcium cyanamide in the third year. The slight decrease in Hopkins acidity and corresponding increase in the pH value of the neutral salt extract

may be ascribed to the cumulative effect of potash and phosphate applied in all three years along with the nitrogenous manure.

5. *The Tingamira Nitrogen Experiment.*

In this experiment the relative value of various nitrogenous manures, applied at a rate equivalent to 40 lbs. per acre nitrogen, together with 20 lbs. per acre each of potash and phosphoric acid in the form of sulphate of potash and superphosphate, is being studied.

Acidities were determined monthly throughout the year 1931, (the first year of treatment).

The various manures tried were sulphate of ammonia, chloride of ammonia, nitrate of soda, calcium cyanamide, blood meal and oilcake. None of the treatments has made a permanent significant alteration in soil acidity after only one year's treatment, so that there is no object in recording the results in detail.

In all cases including the check plots, the acidity increased when nitrification of plant food set in, and during the period of most intense nitrification, that is during May and June, the soil acidity was particularly high, especially on the chloride and sulphate of ammonia plots. By the end of the rains acidities had returned more or less to their original values, and by this time also the nitrates formed in the soil have disappeared.

6. *The Tingamira Cattle Manure Experiment.*

This series comprises 24 plots on which four treatments are replicated six times. The treatments are :—

Series No. 1 ... No manure.
,, 2 ... 5 tons cattle manure per acre per annum.
,, 3 ... 10 ,, ,, ,, ,,
,, 4 ... 20 ,, ,, ,, ,,

One ton of cattle manure per acre supplied about 8 lbs. per acre each of nitrogen, potash and phosphoric acid.

Acidity determinations were made eight weeks after application of manure and again twelve months after application. The

determinations made eight weeks after application indicated a considerable decrease in soil acidity resulting from the heavier applications of manure, but by the end of the year, the soil regained its original acidity. The drop in acidity was due to the presence of free ammonia liberated from the manure and exercising only a temporary effect on the soil acidity.

The results for both sets of determinations are given.

TABLE VII.

Acidities of Tingamira Cattle Manure Experiment Plots.

Tons per acre of cattle manure	Hopkins acidity		pH of soil water extract		pH of neutral salt extract	
	8 weeks	12 months	8 weeks	12 months	8 weeks	12 months
nil	278	355	5·22	5·50	4·12	4·51
5	282	354	5·25	5·44	4·34	4·49
10	244	309	5·33	5·53	4·43	4·56
20	200	315	5·48	5·55	4·53	4·53

The periods after the application of the manure, at which the determinations were made are given above each column. Here again the acidities during the rains are higher than when taken during the cold weather. The temporary effect of the cattle manure in lowering soil acidity must be judged by comparing the manured with the unmanured plots in each set of determinations.

Summary.

1. The general effects of the various manures are :—

   (*a*) Sulphate and chloride of ammonia increase soil acidity.

   (*b*) Calcium cyanamide decreases soil acidity.

   (*c*) Organic manures and nitrate of soda have little or no immediate effect, but when applied in large quantities or over an extended period, decrease acidity slightly.

(*d*) Cattle manure decreases acidity temporarily to some extent but the effect is transient and due to liberation of free ammonia in the soil.

2. (*a*) For low acidity soils, treatment with sulphate of ammonia is recommended until such a time as the acidity has been restored to normal.

(*b*) For normal acidity soils, alternation of two years of sulphate of ammonia with one year of calcium cyanamide is satisfactory treatment for retaining the acidity of the soil at its original value.

(*c*) For soils of very high acidity calcium cyanamide may be used to reduce the acidity to a normal value.

3. The effect of potash and phosphatic manures is to lower the acidity of the soil slightly.

Basic phosphates of course have a considerable effect in this direction owing to their lime content, but superphosphates, containing no free lime, also lower soil acidity slightly.

THE STRUCTURE AND GROWTH OF THE TEA BUSH

BY

W. WIGHT

II. THE TEA LEAF

We are all familar with the external characteristics of a tea leaf. Without any further apology, therefore, I am going to start with the inside of a leaf as seen under the microscope. Fig. I, represents part of an exceedingly thin section of a leaf from the plucking basket. The section is taken at right angles to the plane of the leaf, the line of section passing from edge to edge of the leaf along the narrow diameter. The upper surface of the leaf is towards the top, the lower surface towards the bottom, of the page, and between these two surfaces is represented in outline the mass of the cells which go to make up the thickness of the leaf. For the sake of clarity, the cells are represented almost entirely in outline and without their protoplasmic contents. A section of the leaf taken parallel to either diameter looks very much the same, for, with the exception of the veins, the diameters of the cells are approximately equal in the plane of the leaf. The section shows a covering, or coping, of brick like cells on both the upper and lower surfaces of the leaf. These two bounding layers of cells, technically known as the upper and lower epidermis, are essentially much alike. The outer surfaces of the cells are in each case covered by a thin varnish like film, known as cuticle, and which consists of a cellulose base combined with substances of a fatty and wax like nature. This film serves to render the leaf quite watertight and almost impermeable to gases. It will be noted that the cells in the upper epidermis are in continuity with each other, whilst the lower epidermis differs from the upper in two important respects.

(1) It is perforated by breathing pores.

(2) It carries hairs.

A breathing pore is shown in section at *c* (fig. 1)—it will be noticed that the gap in the epidermal cells is bounded by two smaller and different cells. These two cells are known as guard

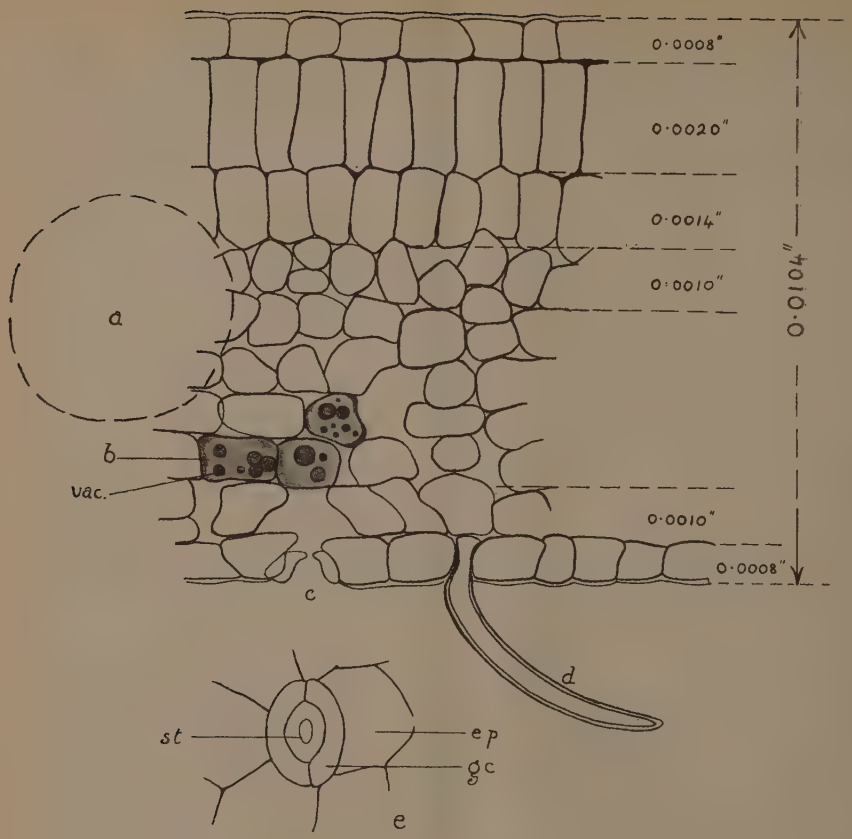

0·0008"
0·0020"
0·0014"
0·0010"
0·0104"
0·0010"
0·0008"
a
b
vac.
c
d
st
ep
gc
e

FIG. I

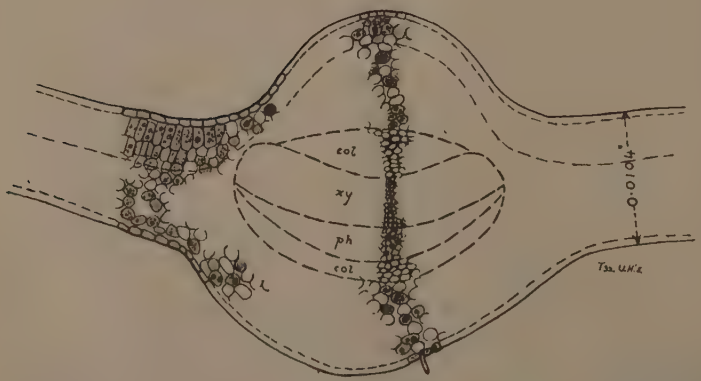

col
xy
ph
col
0·0104"

FIG. II

cells, because, by their movement, they control the intake of gaseous food and the loss of water by the leaf. At *e*, below Fig. 1, a breathing pore (stoma) is shown in surface view, *i.e.*, a small portion of the under surface of the leaf has been greatly magnified. The epidermal cells are seen to be a number of irregular shaped, flattened cells set together like the flagstones in a crazy pavement. The gaps in the pavement are represented by the stomata. Each gap, or stoma, is completely enclosed by two sausage shaped cells (*gc*); these cells, which are set slightly below the level of the epidermal cells, contain chlorophyll and starch grains. The two sausage shaped cells, the guard cells, exhibit great changes of osmotic pressure * (*i.e.*, the degree of concentration of substances active in causing osmosis) from time to time, and consequently, by the withdrawal of water from, or loss of water to, the adjoining epidermal cells, the guard cells become more or less turgid, and, being fastened together at the ends, it can easily be seen that the size of the breathing pores may vary very greatly by a slight movement of the walls of these cells. As will be seen later, the plant both loses water and takes in a large percentage of its food through these pores. The movement of the guard cells (generally spoken of as stomatal movement)

* Wight. The structure and Growth of the Tea Bush. Part I. Quart. Journ. Sci. Dept. I. T. A. Part III, 1932.

FIG. I. *The thickness of a tea leaf in section—semi-diagrammatic. (a) The broken circle indicates the relative size of a vein. The structure of a vein is shown in fig. 2. (b) Mesophyll cells showing protoplasm, and tannins (stained) in vacuoles (vac) in the protoplasm. (c) Stomatal opening (breathing pore). (d) Hair in longitudinal section. (e) Surface view of the lower epidermal cells, showing a stoma. ep. epidermal cell. gc. guard cell. st. stomatal opening.*

FIG. II. *Diagrammatic section (in the same plane as Fig. I) showing the mid rib (leaf stalk). The cellular structure is indicated in part only. The broken lines enclose areas of similar tissue. col. cells containing very little tannin (collenchyma). (xy. wood (xylem.) ph. phloem.)=vascular tissue. Cells containing tannin are fewer in the mid rib than in the rest of the leaf.*

The figures to the right of the diagrams indicate the average size of the cells in the adjacent layers. The surface view of the stoma is to the same scale—the detailed structure of the stoma, such as the thickening of the walls of the guard cells, is not shown. The magnification of Fig. I is 500 diameters, that of Fig. II is 120 diameters.

is greatest in young leaves and least in old leaves. The loss of water in the early stages of wither is probably affected by stomatal movement. It is possible to measure the rate at which gas can be made to flow through the stomata, without damaging the leaf, or even removing it from the bush. Fig. 3 shows the rate of stomatal closure, determined in this manner, on a young leaf withering at a high temperature (108°F). The stomata

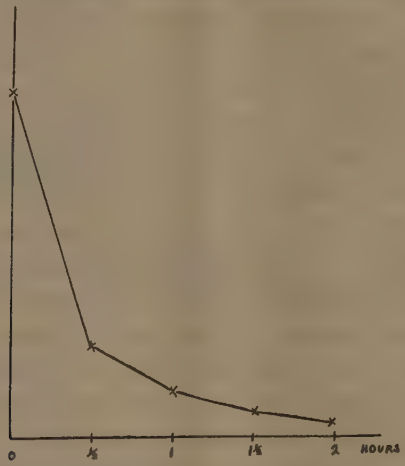


FIG. III.—*Illustrating the closure of the stomata in a leaf withering at a high temperature (108 deg. F). The vertical scale represents the relative flow of gas (under constant pressure) through the stomata at 1/2 hour intervals.*

close very rapidly, and, if the leaf is young, probably completely, thereby hampering further water loss. The actual size of the stomata may be estimated from the scale printed alongside fig. 1. On one square inch of the undersurface of the leaf there are from 10,000-20,000 stomata. The hairs, one of which is shown in section at *d* (fig. 1.), are outgrowths of the epidermal cells, and like the epidermal cells, contain a certain amount of tannin or tannin like, substances. The importance of these hairs in tea manufacture has long been realised. In Java, in 1919, E. L. Siahaija (3) of the Dutch "Proefstation" was giving advice with regard to the production of *white point* tea, *i.e.*, tea composed of silver

and not golden tip, based on a knowledge of the part played by the hairs. Recently, Benton (1), (2), has gone into the subject in detail with regard to the present day methods of manufacture and it is unnecessary to further emphasise the importance of the hairs on the leaf. The length of the hairs varies somewhat from *jat* to *jat*, the range of variation being between 0.006″-0.012″. Variation in the hairiness of the leaf, however, appears to be due mainly to variations in the number of hairs present. On an average sized lower leaf of "two and a bud" the number of hairs per square inch varies from 12,000-13,000 for a good *jat*, to 4,000 for a poor *jat*. When it is realised that the bud represents the same leaf in a more compressed form, it will be seen why the bud itself makes the best tip. Under favourable conditions, with a very hairy *jat*, there is the possibility of the number of hairs on a fully expanded leaf being sufficient to produce the maximum golden colour, the greater number on the bud being ineffective. It is recognised that there are differences in this respect between different *jats*, but the exact nature of these differences is not known. The determination of a reliable "hairiness factor" is engaging the attention of the Botanist at the moment of writing.

The cells in the upper part of the leaf, and below the epidermal layer, are different from those in the lower part of the leaf. Between the two epidermal layers, the leaf tissues are technically divided into two parts, an upper and a lower, called respectively the palisade mesophyll and the spongy mesophyll. Mesophyll means "middle leaf" and the terms are otherwise self explanatory. One, two, or three layers of cells in the upper part of the leaf are long and narrow, regular in size and shape, and are closely packed together like a palisade, without any marked air spaces between the cells. Below these cells, and extending to the lower epidermis, is a region of cells irregular in size and shape, with large air spaces which intercommunicate between and around the cells—the tissue, in fact, is sponge like. The air spaces in the spongy tissue communicate with the external atmosphere through the stomatal openings. The greater part of the chlorophyll is to be found in the palisade layers—the layers which receive the

greatest amount of sunlight—and these layers consequently play a great part in the nutrition of the plant and are to be regarded as a region of food manufacture. It is in the palisade region also, that the greatest amount of tannin occurs, though tannin is also found in considerable quantities in the spongy tissue. A section through the leaf (stained so as to show up the colourless tannins) appears to be triply laminated with regard to tannin distribution : there are considerable quantities of tannin in the upper and lower parts (with most in the upper part) and a region, in the centre of the thickness of the leaf, with hardly any tannin. This is not due to a real difference in the mesophyll tissues, but is caused by the presence of veins. Veins penetrate the thickness of the leaf (somewhere about the middle) in all directions, forming a highly complex network, so that a section taken through the leaf in any direction cuts through a multitude of veins in every possible plane, *i.e.*, in every section from that transverse to the long axis of the vein, to that parallel to the long axis. Consequently a great part of the centre of a section through the leaf is filled with such sections through the veins; scattered, tannin containing cells here and there in the non-tannin central region representing islands of mesophyll tissue surrounded by small veins. There is a sheath of cells, of a nature distinct from those of the mesophyll, partially surrounding each vein, and these cells around the vein are generally free of tannin, thereby accounting for the scarcity of tannins in the centre of the leaf. Fig. 1, is drawn in ideal section through an island of mesophyll tissue. The broken circle (*a*) represents the approximate size and position of a small vein, assuming it to have been cut in a truly transverse plane. Fig. 2 shows the mid-rib of the leaf in the same plane of section as fig. 1, and is intended to show the general characters of a vein. The stalk is the largest vein in the leaf : it will be noticed that the mesophyll cells tend to lose their typical characteristics in passing around the vein. This change of character is most marked around the mid-rib and least marked around the smallest veins. The upper part of each vein consists of wood (*xy*, fig. 2), continuous with the wood of other veins and with that of the stem. The lower part of the vein is composed of a soft tissue known as phloem

(*ph.* fig. 2), (sometimes wrongly called bast), which is also continuous with the phloem of other veins and with that of the stem. The function of this tissue is that of carrying food substances about the plant, and the wood and the phloem are together known as the vascular tissue. Between the two tissues, in the centre of the vein, is a thin layer (0.0002″-0.0004″ thick) of actively growing cells, which keep on adding to the thickness of wood and phloem. This growing tissue (known as the cambium) is best developed in the mid-rib (or stalk) and is practically absent in the very smallest veins. The cambium is also continuous with a similar tissue in the other veins and in the stem. In the stem, the cambium lies between the wood and the bark, the phloem composing the inner part of the bark. The contents of certain of the cells in figs. 1 and 2 have been filled in, assuming that the section has been stained to indicate tannins. The protoplasm is only slightly coloured by the staining reagent, indicating little or no tannin; it will be seen that the greater part of the tannin is located in vacuoles of varying size, the vacuoles appearing as dark masses on a faintly stained groundwork of protoplasm—had a protoplasmic stain been used, the vacuoles would have appeared as cavities in a coloured mass of protoplasm. The scarcity of tannin in the mid-rib is shown in fig. 2 and the non-tannin region around the vascular tissue is also quite clear.

Some account of the origin and growth of the leaf seems appropriate. The stem terminates in the centre of a bud as a very minute dome of growing tissue, known as the growing point. This dome of growing tissue has a radius not usually greater than 0.008″, and when the bud is growing, the rudiments of new leaves are continually being formed in a counter clockwise direction at different points on the periphery of the dome. These leaf rudiments gradually expand and develop, and the vertical distance between them increases, inside the bud. By the time that they appear on the outside of the bud, due to the unfolding of previously formed leaves, the new leaves have got all their tissues fully formed, and further growth is mainly a matter of expansion or simple increase in size without cell division. The bud con-

tains a very definite number of leaves : there is the outermost leaf, wrapped around the outside of the bud like the wrapping of a cigar. In the case of a growing bud, there are five leaves inside the outer wrapping leaf; in the case of the *banjhi* bud, only four. The differences in size of successive leaves, from the outside to the centre of a vigorously growing bud, are shown in the following table.

TABLE I.

I. New leaf just unfolded	II New bud		III		IV		V		VI		VII New leaf in centre of bud
2.56	1.40	0.032	0.620	0.0022	0.240	0.0019	0.0032+	.....	0.0023	0.0009	0.0004
2.28	1.36	0.0019	0.560	0.0019	0.275	0.0021	0.0028+	.....	0.0022	0.0010	0.0002
2.56	1.36	0.0019	0.600	0.0018	0.275	0.0018	0.0063	0.0014	0.0021	0.0011	0.0005
2.44	1.20	0.0022	0.520	0.0017	0.180	0.0018	0.0044	0.0014	0.0018	0.0010	0.0002
2.40	0.88	.....	0.760	0.0020	0.240	0.0016	0.0046	0.0013	0.0020	0.0010	0.0002
2.00	1.04	0.0015	0.480	0.0014	0.180	0.0011	0.0038	0.0013	0.0014	0.0007	0.0002
1.56	0.72	0.0013	0.400	0.0013	0.008	0.0012	0.0031	0.0012	0.0011		0.0001
1.64	0.84	0.0014	0.420	0.0017	0.180	0.0015	0.0051	0.0012	0.0023	0.0009	0.0003

Table I. Size of the different leaves in the bud, expressed as fractions of an inch. Measurements of vigorously growing buds.

Column 1 shows the size of the new leaf just as it is splitting off, or unfolding, from the bud; column 2, the size of the new bud just exposed. Each column (excepting nos. 1 and 7) consists of two sub-columns—the left hand one gives the total length of the leaf—the right hand one the length of the true tip, or point, of the leaf, which blackens, shrivels up and drops off as soon as the leaf unfolds. This tip is a small phalloid structure which may take up in the early stages of development, nearly one half the length of the leaf. The lower part of the rudiment grows rapidly, however, whilst the tip hardly grow at all, develops no chlorophyll, and, on being exposed to the air by the unfolding of a new leaf, blackens and drops off—this tip may be seen on the apex of a bud which has just been exposed by the unfolding of a new leaf. When it drops off, a new point develops on the leaf,

which point, however, usually has a small depression (fig. 4), with the dried up remains of the original tip at its base.

a

b

FIG. IV.—*(a) a young leaf which has just unfolded from the bud, showing the minute point at the apex of the leaf.* *(b)—a similar leaf at a later stage of development.*

The figures show the under surface of the leaf.

Just as little fleas carry lesser fleas, so does one bud contain another. There is a smaller bud at the base of each of the two or three outermost leaves of a bud. Each of these smaller buds contain two or three leaves quite large enough to be removed on the point of a surgeons needle, and at the bases of these leaves in the buds within the bud may be found other, and smaller, rudimentary buds with the beginnings of leaves. Similarly, the *banjhi* bud contains within itself still smaller *banjhi* buds. The "eye" at the base of a leaf is a bud usually containing four to five leaves, and probably rudiments of other smaller buds at the bases of the outermost of these leaves. The outermost leaves of *banjhi* buds, or of a leaf base bud (axil bud), are better described as scales, though they are leaves in a technical sense, differing only from normal leaves in having gone through an arrested course of development. At the base (axil) of each of these small outer leaves of a *banjhi,* or of an axil bud, is another very small bud, which, under natural conditions of growth either does not grow at all, or else produces a flower. Plucking causes these particular buds to "come-away" and produce leafy shoots instead of flowers. The small scales on the outside of a *banjhi* or of an axil bud, or on buds just "coming away" from a clean pruned bush, are not at all noticeable, and soon drop off. After these scales (generally two in number) come one or two

larger unserrated leaves, variously referred to as *janams* or fish leaves, which may remain on the bush for weeks or months before they finally drop off. Following these will be a fully serrated leaf, which, however, will be decidedly smaller than the mean of all the leaves which will be formed above it on the stem. All the leaves, from the insignificant scales at the base of the new stem, to the first serrated leaf, constitute a series of gradually changing leaf forms. Change of leaf type, however, does not stop with the first serrated leaf, nor with the second, nor the third, but continues all the way up the stem, so that the cycle of change is only completed by the formation of another *banjhi* bud. The differences between successive serrated leaves are not immediately apparent, but they are nevertheless real and capable of accurate measurement. Suppose that some definite character of the leaf, such as length, breadth, number of serrations or length of the tip, or point of the leaf, is selected for measurement and the values obtained for successive leaves plotted in the form of a graph; it then becomes apparent that there is a regular and continuous change in each of these characters as the leaf is inserted higher and higher on the stem. In fig. 5 changes in the length of the leaf

FIG. V.—*Length of the leaf point of successive leaves taken from base to bud of a banjhi shoot. The growth of the shoot was completed between two banjhi periods. Vertical scale=length of the leaf point. Horizontal scale=height of the leaf on the stem.*

point are shown—a similar type of curve results if other characters of the leaf are measured. In connection with the continual change of character, a most interesting point occurs. We have seen that the cycle of change is only completed with the formation of another *banjhi* bud. But, supposing that a bush is left unplucked, there comes a time when its fellow bushes cease to flush and begin to go

banjhi; at the same time, the majority of the shoots on the unplucked bush begin to go *banjhi, with the exception of a few of the more vigorous shoots in the centre of the bush.* Some of these shoots form a *banjhi* bud, which however, almost immediately resumes growth and throws off a *janam* leaf which serves to mark off on the stem, the level at which the shoots went *banjhi*—but others of the shoots never form a dormant bud at all and throw off large serrated leaves just as fast or even faster, than normally, and these leaves cannot, by casual observation, be distinguished from those formed during the preceding or succeeding flush periods of the surrounding bushes. Yet, if one of these long shoots, which has continued growth through one or more *banjhi* periods, is taken, and curves for some leaf character are constructed as before, then there will be a number of pronounced dips in the curve, corresponding exactly with the time (or times) at which other shoots on the bush, or on surrounding bushes, were known to have gone *banjhi.* Fig. 6 below shows such a curve, based again on the character, length of leaf tip.

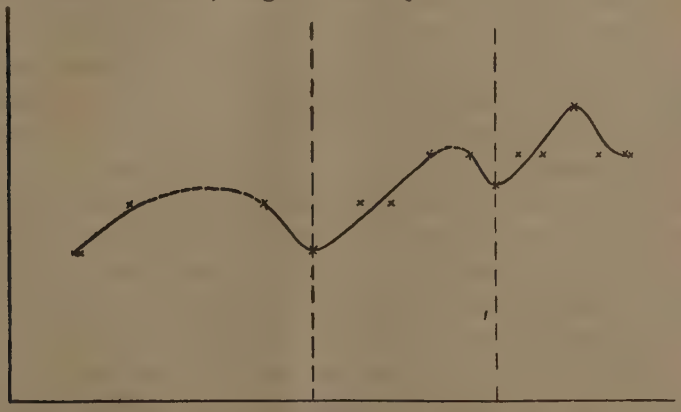


FIG. VI.—*Length of the leaf points on a shoot which has continued growth through two banjhi periods and which ceased growth (went banjhi) at the time of the third banjhi period. Scale the same as for fig. V. The broken lines (vertical) indicate banjhi periods.*

The number of leaves growing outside the bud at any time, is constant. The growing bud, it has already been stated, always contains five leaves inside the enclosing leaf. Of the expanded leaves, below the outer bud-leaf, are four growing leaves and four

only. The fifth expanded leaf, counting down from the bud, has ceased growing. The leaf above this is growing the slowest and will cease entirely when a new leaf unfolds from the bud. Thus, the number of growing leaves, outside the bud, is kept constant, *i.e.*, provided that we do not pluck the bush—a new leaf unfolding and an old leaf ceasing growth, keeps the number of growing leaves outside the bud constant, but the expansion of a new leaf from the outside of the bud would appear to reduce the number of leaves inside the bud by one. This is not so, unless a *banjhi* bud is disclosed by the unfolding of a new leaf, for, in the case of a growing bud, as a new leaf is unfolded, not only does an old leaf cease growth, but a new leaf is formed at the growing point inside the bud, thus keeping the number constant. Leaves, as they unfold from the bud, do so at a definite rate. As a general rule, during the rains, one leaf is unfolded every four or five days. *Janam* leaves are unfolded faster than this, and very often, especially with a long, untipped shoot, the last leaves to be formed before going *banjhi* are unfolded faster than usual. There are certainly seasonal variations in the rate at which leaves unfold, and although large areas of tea growing under similar conditions unfold leaves with the same periodicity, different environmental conditions will almost certainly affect the rate; from the observations of several Dutch planters and scientists (Cohen Stuart (3)) it would appear that altitude, or some factors associated with altitude, is a very potent factor in affecting the rate of leaf unfolding —the difference between sea level and a few thousand feet may mean a doubling of the time required for a leaf to unfold. Analogous, and probably closely related effects of altitude have been recorded (Wight (4)) as affecting the flushing of trees in a temperate climate. The rate at which leaves unfold determines the relation between the type of leaf plucked and the plucking rounds, and this relation is susceptible to accurate analysis. The following considerations will illustrate my point. Let us suppose that the leaves from a single bud are unfolding at a definite rate, say one leaf every four days. A leaf unfolds to-day and we have "one and a bud", or, in other words (so as to obtain a value in figures) we have an expanded leaf value of 1; in four days another leaf

will unfold and we shall then have an expanded leaf value of 2 (*i.e.*, "two and a bud"). To-day we have a value of 1—obviously, therefore, to-morrow we shall have a value of 1¼, because to-morrow the next leaf will be ¼ way towards unfolding. Similarly, the day after to-morrow the next new leaf will be ½ way towards unfolding and we shall have a value of 1½, and so on, until, on the fourth day we have a value of 2, or, two fully expanded leaves (and the bud). If the value or period of leaf unfolding is known—and the great majority of the buds obey the value prevailing at any time—then it is possible to obtain numerical values which tell us at a glance the *actual* leafiness of the shoot on any one day, the value taking into account the degree of development, or potentiality, of apparently similar buds. When these considerations are applied to the plucked bush, various other factors have to be taken into account, *e.g.*, zero value will not apply to a bud which is just "coming away" but has not yet produced any leaves, but to a shoot, the bud, and the bud only, of which is just sticking up above the plucking level. Again, owing to the diverse degrees of development of shoots all over the plucking surface, we cannot at any time consider all the shoots to be in a zero condition. The shoots could be in any stage of development and have any values above zero, were it not for the fact that plucking limits the upper range of development to a value of 1¾—to the plucker a value of 1¾ is "one and a bud", but a value of 2 would be "two and a bud" and would consequently be removed *. Our lowest value, therefore, for the plucking surface will actually be a range of values from 0 to 1¾, progressing in quarters, and this range will represent the relative condition of every shoot on the bush, with respect to the plucking level. Cohen-Stuart (3) many years ago realised the importance of the *leaf-period*, (*i.e.*, the period which a leaf takes to develop) and discussed the matter in some detail. Due to different systems of plucking, whereby the shoot determined the plucking level, rather than *vice-versa*, his tables are not now directly applicable. I have taken Cohen-

* This argument is based on a system of plucking whereby all, or most of the "1 & a bud" shoots are left on the bush. A similar line of argument, of course, can be used to analyse any system of plucking.

Stuart's mode of attack and applied it to our present conditions, with the following results (Table 2). A number of columns are set out corresponding in number to the number of values into which the different shoots on the surface of the bush may be grouped. More shoots will fall into one value or class, than into another, but most shoots will fall into, or very near to, the mean class, with a lesser number of shoots associated with the columns to the right and left of the mean : this is important, because the adoption of a seven-day plucking round depends partly on a practical realisation of this fact. Table 2, printed below, shows the range of variation in shoot values immediately after plucking, and the increase in these values (on our original assumption of a four day leaf-period) from day to day.

TABLE II.

Shoot value								
0	¼	½	¾	1	1¼	1½	1¾	Plucking surface jut after plucking
¼	½	¾	1	1¼	1½	1¾	2	„ „ 1st day „
½	¾	1	1¼	1½	1¾	2	2¼	„ „ 2nd „ „
¾	1	1¼	1½	1¾	2	2¼	2½	„ „ 3rd „ „
1	1¼	1½	1¾	2	2¼	2½	2¾	„ „ 4th „ „
1¼	1½	1¾	2	2¼	2½	2¾	3	„ „ 5th „ „
1½	1¾	2	2¼	2½	2¾	3	3¼	„ „ 6th „ „
1¾	2	2¼	2½	2¾	3	3¼	3½	„ „ 7th „ „
2	2¼	2½	2¾	3	3¼	3½	3¾	„ „ 8th „ „

Table II. *Leaf development on a plucked bush, with an assumed leaf period of four days. The leaf which would be plucked is enclosed by the heavy lines. Plucking on the 7th. day should produce nearly twice as much leaf as on the 4th. day. The 7th. day after plucking is the last day on which there is a majority of "2 and a bud" shoots, and on that day many of the "3 and a bud" are "only just" 3 and a bud. On the 8th. day, one half the shoots are "3 and a bud" above the plucking surface.*

(1) If a leaf unfolds in n days*, the ideal plucking round, considering all the leaves, and trying to obtain ideal leaf in the plucking basket, in every n days. (The nearer one gets to this period, the less over ripe leaf one gets, as by method (2) below).

(2) A more practical plucking round, based only on the mean † condition of the shoots, and plucking so as to obtain the maximum size of "two and a bud" without going to "three and a bud", is every $2n-1$ days. (This method gives a certain amount of "three and a bud", which should be plucked as "two and a bud". By method (1) above, all the shoots can be plucked right down to the previous plucking level.)

The correct mean value and the seasonal variation of the leaf-period of tea growing in the plains of Assam, has yet to be determined. Four to five days is a safe working basis; taking four days, so as to be on the safe side for fine plucking, shows the seven-day round to be undoubtedly the best practical plucking round, with the possibility of a four-day round as a theoretically ideal plucking round from the point of view of obtaining fine leaf. Any shorter round than this would, at the least, be a sheer waste of time. In practice, the plucking round obviously becomes automatically adjusted to the leaf period (labour being adequate), so that if the plucking is all that it should be, one could estimate the rate at which leaves are unfolding, from the plucking round itself. Consequently, a reversal of the above argument is of the most practical interest: it follows from (2) that if the longest plucking round possible, without getting too much "three and a bud", is being practiced, then the shortest period that one could employ would be obtained by increasing the plucking time by 1 and dividing the sum so obtained by 2, *e.g.*, with a present plucking round of 7 days, the shortest possible round is $\frac{7+1}{2}$ days $=4$ days; with

* Where n equals any particular number.

† The mean will either coincide with the median value or be slightly to the left of it, according as to whether the distribution is normal or positively skew—a negative skew is not likely.

a present round of 5 days, the shortest possible round is $\frac{5+1}{2}$ days = 3 days. Of course, whether such a procedure were adopted would depend on available labour and financial considerations.

In the foregoing paragraphs much has been said about the structure and growth of the leaves. One may legitimately ask the question, "What are the leaves for?" Functionally, they are the feeding and breeding organs and the "sweat glands" of the plant. Carbon dioxide, a gas present in small quantities in the atmosphere and composed of two parts of oxygen with one part of carbon (*i.e.*, lamp black, soot, graphite), diffuses through the stomata into the intercellular spaces in the lower part of the leaf. The cell walls surrounding these spaces are saturated with water, in which the carbon dioxide dissolves and is passed, in solution, from cell to cell, till it reaches the palisade cells, where, in the presence of chlorophyll and under the influence of sunlight, it is made to combine with the elements of water to form a sugar. This sugar eventually takes the form of grape sugar (glucose) and as such is the basic food material of the plant. For every volume of carbon dioxide taken in by the leaf, an equal volume of oxygen is given out, for the leaf, in effect, extracts the carbon and throws away the oxygen. Man breathes oxygen and expires carbon dioxide as a result; it is, therefore, easy to see that a purification and revitalisation of the atmosphere is carried out by plant leaves, which are, at the same time, feeding themselves. "Feeding themselves" is no stretch of the imagination, as an analysis of the plant will show. In Table 3 below is set out a plant analysis, which may be taken as a general average for most plants.

TABLE III.

The plant consist of free and easily removable water ...	80%
Of the dry material left after removing water we have	
Carbon	45 %
Oxygen	42 %
Hydrogen	6·5 %
Nitrogen	1·5 %
Ash *i. e.*, material left after burning the dry matter and represents the difference between carbon, oxygen, hydrogen, nitrogen and the dry weight	5 %

The 5% ash, *i.e.*, 1% of the actual weight of the plant, may be composed of any or all of the following substances—potassium, sodium, calcium, magnesium, iron, manganese, sulphur, phosphorus, silica and chlorine. Thus, apart from water, very little of the bulk of the plant is derived from the soil, but most of it from the atmosphere. What makes this fact more remarkable is that the atmosphere contains only 0.03% by volume of carbon dioxide, thus indicating considerable efficiency on the part of the leaf. The carbon dioxide is so slightly soluble in water that the absorption of the gas by a piece of moistened blotting paper of equal size, shape, thickness and water content to a leaf, would be utterly negligible. Yet 100 sq. ft. of leaf (sunflower) can absorb approximately 7.1 cubic inches of carbon dioxide per hour. In 10,000 cubic inches of air there is only 0.009 oz. of carbon combined as carbon dioxide. A single maize plant (of a size such as is grown in middle Europe) has to remove all the carbon from 133,824,000 cubic inches of air in order to obtain the carbon necessary for its structure. The weight of such a quantity of air would be equal to 3.1 tons. Based on this estimate, an acre of maize requires 18,600 tons of air to feed it in order that it may produce a crop. There is not the slightest doubt that these figures will be exceeded by an acre of tea, and in any case the estimates may be multiplied by three or four in order to get a figure for a crop which is on the ground for a whole year.

Sugar which is not immediately used by the plant is stored as starch—another, and insoluble, carbohydrate : large quantities of sugar in solution would raise the concentration and osmotic pressure of the cell sap to an extent that would interfere with the activity of the leaf. The plant, however, is constantly feeding, and when necessary, draws upon the starch reserves Assimilation of carbohydrates formed by the leaf is essentially the same as the assimilation of any carbohydrate (such as bread) by an animal, and is a respiratory process—oxygen is absorbed and carbon dioxide given out, respiration thus, in some measure, reversing the gas exchange due to photosynthesis * (*i.e.*, the process whereby

*The word photosynthesis may be translated as "a building up under the influence of sunlight".

the carbon dioxide was taken in and manufactured into food). Respiration in man oxidises or burns up his food with the production of heat and energy—respiration in the plant serves the same purpose and provides the energy, not for wielding a hoe or playing tennis, but for the formation of new leaves. In addition to the feeding functions of the leaf, is that of getting rid of water, *i.e.*, "a sweat gland". The roots of the plant draw up an enormous quantity of water from the soil, and only a small portion of this water is retained by the plant, *e.g.*, a maize plant in the course of its life will evaporate from the lower surface of its leaves about 55 gallons of water. Of the total amount of water taken in by the roots, the plant will retain only 0.15 – 0.2% by weight. Figures of a similar order will apply equally well to tea. Consideration of these facts will show that the leaf is a very active and very important organ of the plant. Of critical importance to the leaf are the breathing pores (stomata); it will be seen that anything which blocks the stomata, either partially or completely, or in any way impedes the flow of air to the leaf, will affect the health of the bush and may thus lead to a reduction in crop.

Bibliography

Maximov. *"A Text Book of Plant Physiology"*. (English transl. Ed., by Murneek and Harvey.) New York. (1930).

Miller, Edwin C. *"Plant Physiology"*. New York. (1931).

References

(1) Benton, S. F. The Greying of Tea. Indian Tea Assoc. Sci. Dept., Quart. Journ. III: 139-144. 1931.

(2) Benton, S. F. The Production of Golden Tip. Indian Tea Assoc. Sci. Dept., Quart. Journ. II: 95-100. 1932.

(3) Cohen-Stuart, C. P., E. Hamakers, E. L. Siahaja. Proeven over den Theepluk. Mededeelingen

van het Proefstation voor Thee LXV. Batavia. 1919.

(4) Wight, W. Secondary Elongation Growth in Oaks, 1929. The Naturalist. Feb. 1930. 65-70.

Addenda—The Structure and Growth of the Tea Bush. Part I. Owing to an oversight, the part of the cells marked *nu* on figs. I and II, was not referred to in the text below the figures. The text should read as follows :—

c.w. *cell wall.*
vac. *vacuole.*
pp. *protoplasm* (*shaded*).
pl. *plastid.*
nu. *nucleus.*

EDITORIAL NOTE.

Reference to the article entitled "The Production of Golden Tip" in Part II, Quarterly Journal, 1932. On page 99 a reference is made to a sorting machine of the Moore type. In order that there may be no misunderstanding I wish to draw attention to the fact that the Moore machine is referred to as being typical of sorting machines working on the principle of moving trays inclined usually at a slight angle to the horizontal. The Moore being a well-known machine was referred to as representing the type. It must not be thought that the reference is only to the Moore machine but it applies to all machines working on that same principle.